An Approach to Technology Transfer within the Canada-Ontario Green Plan

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Disclaimer: *The views contained herein do not necessarily reflect the view of the Government of Canada, nor of the Canada-Ontario Green Plan Technical Transfer Committee*

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Executive Summary

The objectives of this study were:

- to compile a list of all of the projects undertaken as part of one of the components of Green Plan in Ontario, since the conclusion of SWEEP.
- to recommend improvements to the system of technology transfer in Ontario to promote the transfer and adoption of the information generated from these projects.

The titles, principal researchers, objectives and results achieved or expected of 177 individual projects within eleven programs or sub-programs were compiled into lists. These projects covered a wide range of activities including: literature reviews, surveys of farmers' attitudes or farming practices, scientific studies, computer software development and on-farm demonstrations. Within the listings, projects were grouped according one issue that provided the main focus for the project. These areas were patterned after those used within the Environmental Farm Plan Workbook.

In anticipation of recommending changes to the system of technology transfer in Ontario, the Technology Transfer Committee recommended that the development of a revised system of technology transfer for be used as a pilot project. Accordingly, the issues raised by manure management were considered in some detail. Manure management may represent the ultimate challenge in transferring sustainable technology, since it presents the difficulty of designing an **affordable** system for collecting, storing, transporting and applying manure which **minimizes the risk of contamination of air, surface water and groundwater,** at all stages in the system, **without significant agronomic or operational problems**. Current recommendations offer few guidelines in dealing with this complexity to farmers, who seem faced with an impossible set of demands. It is essential that a harmonized set of environmental targets be established for contaminants from manure, along with a process by which farmers can design practical and affordable systems to achieve them.

Within Ontario, the Ontario Agricultural Services Coordinating Committee (OASCC), the eight Research and Services Committee which report to it, exist to provide coordination of agricultural research and the formulation and delivery of recommendations. Since OASCC was formed changes have occurred in Ontario relative to discovery, development and transfer of technology, such that much the information being generated in the province is not reported through OASCC nor integrated into recommendations:

> Much research, even at public institutions, is now funded by sources other than OMAFRA or AGRICULTURE AND AGRI-FOOD CANADA, each with its own reporting mechanism.
> A substantial amount of research that affects agriculture is done within institutions, farms, businesses or organizations outside the OASCC system.

Technology transfer in Ontario has tended to follow the traditional extension model, in which information is perceived to flow in steps from researchers/developers through a recommending body, to public sector extension personnel or private sector sales representatives and then to farmers. In the past, the level of information available and the system that delivered it, suited

the times and technology was transferred very effectively. However, because technology is being developed or adapted at almost all levels of the system (i.e. researcher, extension, private sector and farm) and at a multitude of sources external to it, information flow is becoming increasingly multi-directional and less coordinated. It is doubtful if the system, as it is currently structured, will be adequate in the future:

In transferring detailed information, Ontario remains highly dependent upon personal contact, the preferred method of learning of many farmers. Farmers, however, have become very diverse in their abilities to obtain, assimilate and apply information, and will be more selective about the format in which they will accept information.

Farms have become so diverse and so specialized, that each farmer's informational needs are almost unique, in respect to both the questions to be answered and the level of detail sought. Some farmers are looking for the specific information they need to implement a technology, while others still require general materials to raise awareness and promote experimentation.

Even to experiment with a new technology can necessitate a large capital investment for a farmer and thus pose a large risk for him or her. Increasingly, farmers will require a package of information complete enough for them to visualize how the entire system can be made to work, profitably, on their farm before they will try it.

The amount of information now available and the level of detail being requested are beginning to seriously tax the system for extending information in Ontario, especially in an era when the number of personnel is being reduced at all levels within the system.

It does not appear feasible to attempt to transfer "packaged" systems, at this time, given the diversity and complexity of most farm operations, but clients should be able to obtain information on all components of the system they are assembling.

The extension system has generally served Ontario agriculture well, and continues to do so despite the limitations noted above. However, these limitations must soon be addressed, since their effects will likely become more significant in the future.

The current system for technology transfer in Ontario does represent a solid base upon which to make improvements. Much of the information required by our clients can be transferred using existing agencies, organizations and communications technology, with appropriate modification and supplementation.

Recommended Goals:

1) Information must presented in ways that will allow potential users to assess the impact of a change in technology on their production system and the environment.

2) An effective alternative to direct contact with experts must be developed to transfer detailed information to clients.

3) The technology transfer system must ensure that the best available information is widely accessible in formats that will facilitate widespread usage.

Recommended Objectives:

1) For each issue area, an individual, or group, should be assigned the task, and held accountable, to ensure that, as information becomes available, it is:
   - assembled at a central location, preferably in both printed and electronic formats.
   - reviewed and integrated with previous information, noting whether they support current recommendations or necessitate change.
   - summarized with previous information.
   - presented, with draft recommendations, to the appropriate OASCC committee for review.
   - available to extension personnel and private sector sales staff, in a readily usable form.

2) To ensure that the summarization of data in this manner will occur, it is likely that funding will have to be provided specifically for this task.

3) Design of projects on related topics should be coordinated to facilitate integration of their results. Collection of a standard dataset should be encouraged, as appropriate.

4) Information from on-farm demonstrations and experiments should be integrated into the reviews outlined above. Use of a standard design for on-farm plots and collection of a standard dataset should be encouraged, especially where the work is conducted with public sector input (e.g. OSCIA and Rural Conservation Clubs).

5) Extension materials should be designed to meet the needs of specific client groups, with regard to the level of detail and format. In such materials, either printed or electronic, the pathway by which a user can obtain more information must be clear.

6) All extension materials related to a particular topic should be available, or accessible, through the same location.

7) Production recommendations and related information should be organized and presented in ways that facilitate use of a systems-approach in considering and applying new technology.
8) Extension material should outline the potential impact of a technology on both other parts of the farm system and the environment or indicate where such information can be obtained. Prerequisites for implementing the technology on a farm should also be identified.

9) Materials should be developed to assist farmers in comparing the costs and benefits of alternate technologies, objectively, relative to both farm and environmental goals. Through such an approach, farmers should be able to arrive at a least-cost, practical system.

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Introduction

Canada's Green Plan lists three objectives vital to achieving sustainable agri-food systems:

- to conserve and enhance the natural resources that agriculture uses and shares.
- to be compatible with other environmental resources that are affected by agriculture.
- to be proactive in protecting the agri-food sector from the environmental impacts caused by other sectors and factors, external to agriculture.

Over the past decade, Green Plan has provided funding for many research, development or demonstrations projects aimed at furthering these goals, and much useful information has been collected. The success of program, however, cannot be measured only in terms of the amount of information produced. The program can be considered successful only if the information and resulting recommendations are disseminated to the agri-food sector, and to the public in general, in ways that result in their application towards attainment of the Green Plan objectives. It was towards this end that the Green Plan Technology Transfer Committee contracted for this project.

Objectives

1) To compile a list of all of the projects undertaken as part of one of the components of Green Plan in Ontario, since the conclusion of SWEEP.

2) To recommend improvements to the system of technology transfer in Ontario to promote the transfer and adoption of the information generated from these projects.

Compilation of Canada-Ontario Green Plan Projects

Before beginning to develop a technology transfer strategy for information generated within Green Plan, it was necessary to assemble a list of the research and demonstrations projects conducted as part of the Canada-Ontario Agriculture Green Plan. (The contacts and sources from which the lists were compiled are shown in Appendix A.) The following programs were included in this compilation:

Program Title	Dates	Abbrev.
Previous Programs:		
Ontario Land Stewardship Program	(1987-1990)	(LS)
Soil Quality Evaluation Program	(1989-1994)	(SQEP)
National Soil Conservation Program	(1989-1993)	(NSCP)
Great Lakes Water Quality Program	(1989-1994)	(GLWQP)
Ontario Land Stewardship II Program	(1990-1993)	(LSII)
Environmental Sustainability Initiative	(1992-)	(ESI)
Land Management Assistance Program	(1992-1994)	(LMAP)
Current Programs:	(1993-1997)	
Rural Conservation Club Program		(RCC)
Manure/nutrient Management and Closed Loop Recycling		(MA)
On-Farm Research		(RF)

A total of 177 individual projects within these programs were included in this summary. These projects covered a wide range of activities including: literature reviews, surveys of farmers' attitudes or farming practices, scientific studies, computer software development and on-farm demonstrations. Some of the latter provided only notes on the co-operators' observations, but add to the useful knowledge, nonetheless.

To provide some structure to the listings, categories identifying one main environmental or agronomic issue were established, so that projects could be sorted according to their primary focus (Table 1). These categories were patterned roughly after those used to define the modules of the Environmental Farm Plan (Appendix B), with some modification. Some projects did not fit an EFP module topic and so many projects dealt with certain facets of some modules (e.g. manure application), that it was useful to sub-divide the categories.

Appendix C contains a list of the titles of the projects under each of the above programs, along with the principal researcher or contact, the lead agency for the project and codes by which the project is identified throughout this report.

Appendix D lists the titles of projects within each issue area, the principal researcher or contact, the lead agency for the project and codes by which the project is identified throughout this report. The distribution of projects by issue area in tabular form and the year in which each project is to be completed are illustrated in Table 2. (Many projects will also provide useful information on issues other than those which represent their main focus. The lists should be cross-referenced between issue areas, but this has not been done to date.)

Appendix E contains a brief summary of lists the projects within each issue area, outlining their objectives and results achieved or expected. (Because of time constraints, summaries for projects in SQEP and GLWQP are not yet included. Summary reports of both of these programs have been published and are available through Agriculture and Agri-Food Canada.)

Table 1: Issue areas used to sort Green Plan research and demonstration projects

Code*	Issue Area
1A:	Development of Methodologies to Evaluate Soil Quality
1B:	Soil Erosion Measurement and Prediction
1C:	Development of Methods to Monitor and Map Soil Resources
2A:	Agriculture and Water Quality
2B:	Drinking Water
2C:	Agricultural Chemicals and Water Quality
2D:	Alternate Water Supply for Livestock
16:	Nutrient Management
11:	Treatment of Milkhouse Washwater and other Contaminated Water
17A:	Manure/Nutrient Management - General
17B:	Nitrogen and Carbon Transformations in Manure During Storage and Handling or in Soil
17C:	Effect on Water Quality of Manure Source and the Rate, Method and Time of Application
17D:	Use of Urban Organic Wastes on Farmland
18A:	Horticultural Crops: Soil Management
18B:	Horticultural Crops: Greenhouse Management
19A:	Conservation Cropping Systems - General
19B:	Cropping Systems and Water Quality
19C:	Cropping Systems and Soil Properties
19D:	Conservation Cropping System Demonstrations
20A:	Pest Management: Field Crops
20B:	Pest Management: Horticultural Crops
21:	Wetlands and Streambanks
23:	Woodlots and Wildlife
24:	Other

* Issue code numbers are patterned after those used in the Environmental Farm Plan.

Issue Area Summaries

The following are brief summaries of the types of activities undertaken in the projects included in the various categories.

1A: Development of Methodologies to Evaluate Soil Quality

- evaluate methods to measure spatial and temporal variations in soil biomass;
- assess the suitability of soil organisms and/or soil biological activity as bio-indicators of soil quality;
- assess changes in soil physical quality, and their effect on crop productivity.

1B: Soil Erosion Measurement and Prediction

- evaluate methods to measure or predict the amount and distribution of soil erosion.
- survey soil Cesium-137 contents across the province to provide a baseline against which to compare future estimates of soil loss.

1C: Development of Methodologies to Monitor and Map Soil Resources

- evaluate methods to upgrade resource maps and databases used to define, illustrate or report the quality, extent or sustainability of agricultural resources.
- compare the suitability of methods used to present such information as a basis for decision- or policy-making.
- develop a computerized database with a standardized format for recording and summarizing the results of agricultural resource monitoring projects.

2A: Agriculture and Water Quality

- determine the mechanisms of contaminant movement from agricultural land into surface or ground waters, including macropore flow.
- estimate the potential impacts of agriculture on water quality, on a regional basis.

2B: Drinking Water

- survey the quality of water from farm wells across Ontario.
- develop and demonstrate methods to protect or improve farm wells and the quality of their water.

2C: Agricultural Chemicals and Water Quality

- develop criteria for determining the threat to water quality posed by various classes of pesticides.
- determine the relative importance of the mechanisms by which agricultural chemicals degrade water quality.
- estimate loading of agricultural chemicals into Great Lakes from non-point sources.
- develop biomonitoring systems to assess the impact of agricultural chemicals on stream sediments.
- investigate the atmospheric deposition of agricultural chemicals.

2D: Alternate Water Supply for Livestock

- demonstrations of ways to supply water to livestock, denied access to streams.

Table 2: Issues Addressed by Canada-Ontario Green Plan Projects and Completion Times

Issue Area	Completed Projects	Projects Ending in: 1995	1996	1997	#
Development of Methods to Evaluate Soil Quality	LS 7016; SQEP 4,7,9 ESI - 1; NSCP 1,2	MA 11, MO 01	MO 02	MA 07, MO 03 RCC 73	13
Soil Erosion Measurement	SQEP 6; NSCP 10		MO 08		3
Monitoring and Mapping Soil Resources	SQEP 1,2,3,12 MO 04	MO 05, MO 06 MO 07	MO 09, MO 11		10
Agric. and Water Quality	NSCP 3,4 GLWQP X?,14			MO 10	5
Drinking Water Quality	ESI 2; LMAP 1,2			RCC 56,79	5
Pesticides & Water Qual.	SQEP 10 GLWQP 1,2,3,5,6,7,8,11,13				12
Livestock Water Supply	LSII 32,48,107		RCC 88		4
Waste Water Treatment	LSII 28			RCC 15,33,90, 98,102,104	7
Nutrient Management	LS 7017,7020,7018; NSCP 5 LSII 26,29e,59,89,100 LMAP 15/94; GLWQP 09			RF 05 RCC 115,125	14
Manure: General	MA 01			MA 10	2
Manure: N & C Dynamics	NSCP 6; LSII 74 LMAP 13/94			MA 02, MA 03, MA 04	6
Manure Management and Water Quality	LSII 40,66,99,113 NSCP 7; GLWQP 10			MA 05; RF 02 RCC 29,72	10
Urban Wastes on Farmland	LSII 43; SQEP 11			MA 06 RCC 96,99	5
Hort. Crops: Soil Mgt.	LS 7005,7019,7009 LSII 60,87,102			RF 07 RCC 59	8
Greenhouse Management	LSII 72,91				2
Cropping Systems: General	LS 7008; LSII 71; RCC 45			RCC 78	7
Cropping Systems: Effect on Water Quality	NSCP 8 LMAP 16/94			RF 03, RF 06 MA 08, RCC 17	6
Cropping Systems: Effect on Soil Properties	LS 7002,7006,7007,7015, 7004,7011,7012,7013 NSCP 9,11			RF 04	9
Cropping Systems: Demonstrations	LSII 7,22a,b,29a,d,35,58, 61,65,80,81,105,106,115 RCC 110a,110b,122	RCC 34,97		RCC 09,42,67 68,84	23
Pest Mgt.- Field Crops	LSII 23,63,19c,70 GLWQP 4,12			RCC 8,25,75	7
Pest Mgt.- Hort. Crops		RCC 16		RCC 76,120	3
Wetland Mgt. or Construction	LS 7010; LMAP 6,7,14/94			RCC 14,77,92	7
Woodlots & Shelterbelts	LS 7000,7003,7014			RCC 117	4
Agriculture and Wildlife	LSII 87; LMAP 9,10; MA 09				4
Community Supported Agric.	RCC 48				1
On-farm Research Methods	RF 01				1

For project titles, refer to Appendix C.

16: Nutrient Management

- examine effects of tillage systems and cropping systems on soil nitrogen dynamics, losses and availability (includes conservation tillage, cover crops and crop rotations, especially involving legumes).
- evaluate and demonstrate the soil test from nitrate-nitrogen as a means of establishing nitrogen requirements for various crops (mainly corn).
- on-farm demonstration of fertilizer application methods for conservation tillage.

11: Treatment of Milkhouse Washwater and other Contaminated Water
- on-farm evaluation and demonstration of vegetated filter strips, constructed wetlands or tile beds for treatment of contaminated water.

17A: Manure/Nutrient Management - General
- literature review of the current state of knowledge on manure-nutrient management and its environmental impacts.
- investigate the effectiveness of manures in controlling soil-borne plant pathogens

17B: Nitrogen and Carbon Transformations in Manure During Storage and Handling or in Soil
- examine the transformations of carbon and nitrogen, including losses to the atmosphere or water, which occur during collection, storage, handling, treatment or spreading of manure from various types of livestock and storage systems (including composting).
- examine transformations of carbon and nitrogen occurring after spreading of manure from various types of livestock and storage systems (including composting).

17C: Effect on Water Quality of Manure Source and the Rate, Method and Time of Application
- determine the mechanisms by which nutrients and bacteria from manure, especially liquid, are transported to surface or ground water.
- monitor the impact of manure application on water quality.
- investigate methods of integrating manure application into conservation tillage systems to reduce the risk of contamination of air or water.
- survey the nutrient contents of manures from a range of farm operations and measure actual application rates and spreading patterns.

17D: Use of Urban Organic Wastes on Farmland
- assess the environmental, agronomic and economic impacts of the application of urban organic wastes on farmland.

18A: Horticultural Crops: Soil Management
- develop and demonstrate cover crops, improved crop rotations and conservation tillage systems for horticultural crops.

18B: Horticultural Crops: Greenhouse Management
- identify and promote greenhouse management practices that support environmental sustainability.

19A: Conservation Cropping Systems - General

- survey of costs associated with various cropping systems (E-Plus program).
- survey of farmer attitudes towards soil conservation.
- literature review of Ontario information on no-till (1992).

19B: Cropping Systems and Water Quality
- measure effects of cropping and tillage systems on water quality.

19C: Cropping Systems and Soil Properties
- measure the effects of various cropping systems on soil properties and crop yields.
- determine, and develop ways of overcoming, the factors limiting crop performance in conservation tillage systems on clay soils.
- literature review pertaining to buffer strips.

19D: Conservation Cropping System Demonstrations
(Land Stewardship II and Rural Conservation Club programs.)
- on-farm demonstrations and comparisons of conservation cropping systems (includes tillage, fertilizer application, variety selection, strip-cropping, cover crops).

20A: Pest Management: Field Crops
- development, demonstration or comparison of systems to reduce pesticide use in field crops (includes rootworm monitoring, band spraying, vegetation-detecting sprayers, controlled drainage).

20B: Pest Management: Horticultural Crops
- development, demonstration or comparisons of non-chemical methods of controlling Colorado potato beetle.
- evaluate systems of water and chemical management in turf.

21: Wetlands and Streambanks
- demonstrate wetland restoration and management of adjacent lands.
- develop a computer model to assist in the design and locating of ponds, artificial wetlands and infiltration systems.
- assess methods for monitoring the impact of artificial wetlands on the quality of surface and ground waters.
- evaluate the suitability of several species of trees and shrubs for streambank stabilization.

23: Woodlots and Wildlife
- develop an improved system for designing shelterbelts.
- investigate a variety of aspects of the interactions between trees and crops (e.g. intercropping, riparian strips, shelterbelts, sugarbush management)
- literature review of the impact of wildlife on agriculture, and vice versa, leading to recommendations for improved management of wildlife habitats on farms.
- demonstrate integration of wildlife habitat enhancement in farm plans.

24: Other
- community assisted agriculture
- literature review of methods to conduct and evaluate on-farm research

Manure Management - A Case Study in Complexity

In anticipation of recommending changes to the system of technology transfer in Ontario, the Technology Transfer Committee recommended that the development of a revised system of technology transfer for manure management be used as a pilot project. Accordingly, the issues raised by manure management were considered in some detail. (This report does not contain a full review of the technical and environmental issues related to manure management, because that was the focus of one of the Canada-Ontario Green Plan projects. See MA 01/94, *Literature Search on Manure/Nutrient Management*.)

Manure management may represent the ultimate challenge in transferring sustainable technology, since it represents the difficulty of designing an **affordable** system for collecting, storing, transporting and applying manure which **minimizes the risk of contamination of air, surface water and groundwater,** at all stages in the system, **without significant agronomic or operational problems**.

Figure 1 and Table 3 together illustrate this complexity, although both oversimplify the situation.

Note: The numbers used in brackets throughout this section and to label the parts of Figure 1, refer to the corresponding sections of Table 3.

Figure 1 graphically shows possible pathways of manure movement from its source to the field, and the points and processes at which contaminants (1a & 1b) can be lost into the environment. At virtually every stage, there is the potential for contamination of the air or water or both, with a variety of contaminants.

At each stage depicted in Figure 1, farmers can choose among several options for facilities or equipment (Table 3b). These can be combined in a variety of ways to produce a multitude of possible manure handling systems (although some choices limit the options available at later points in the system).

Gases produced by livestock during digestion (2a) can be expelled directly from the animals or released from the manure after excretion.

Manure produced by livestock (3) can be deposited in confined areas, such as barns or barnyards, in pasture or directly into surface water (2e) if access is not restricted. Rainfall and other water running off such areas will be contaminated with manure or its constituents (2i). Contaminated water should be directed into either a liquid manure storage area or into a separate reservoir or treatment facility for contaminated water (7). Depending on surface material and the soil type, nitrates could leach into the groundwater from yards and surrounding areas (2L).

In some cases, areas where manure is deposited also serve as the storage (6), (e.g. manure packs and liquid storages under slatted floors). Otherwise, manure must be collected and transferred to storage (5) or spread directly on the field. Ammonia, carbon dioxide or methane may be released as the manure decomposes in storage (2b). As with open yards, rainfall or other water running off the storage area will be contaminated with manure or its constituents (2i), and nitrates can leach from improperly designed or constructed storage areas (2L).

When the situation dictates, manure is removed from storage and transported to the field for spreading (8). Farmers must consider a range of soil, crop and farm management factors to determine the time, method and rate of application (4). During application contaminants may enter surface water directly through spills (2f), drift (2g) or misapplication (2h).

After application, gases are released through volatilization of previously produced gases (2c), continued decomposition (2b) or denitrification (2d). Surface water can be contaminated by runoff (2i), soil erosion (2j) or flow through soil macropores to tile drains (2k). Depending on the soil type and management practices, nitrates can leach into the groundwater (2L). (Figure 2 provides a more detailed illustration of nitrogen transformations in soil.)

From virtually every perspective, manure handling is a complex problem. Environmentally, no one system appears to reduce all of potential problems simultaneously.
Consider some examples:

1) Use of a liquid manure system generally reduces the risk of contamination of runoff from the storage (as compared to solid), but increases the likelihood of contamination by macropore flow after application and tends to cause more odours problems.

2) Irrigation reduces the risk of soil compaction, but likely increases loss of ammonia by volatilization, as compared to application by tanker. Injection of manure should reduce ammonia loss and odour problems, but appears to increase the risk of denitrification.

Table 4 lists several Best Management Practices contained in *Livestock and Poultry Waste Management*, their likely effect on contamination of air or water, and other complicating factors, related to manure application. (Each of the options available for storing and handling manure also has its own set of environmental impacts.) All of the practices listed, simultaneously improve some problems and worsen others. By comparison, conservation tillage (e.g. no-till or mulch-till), although also complex to implement, at least tends to lessen most of the environmental problems related to crop and soil management.)

Current recommendations offer farmers few guidelines in dealing with this complexity. **Farmers face a seemingly impossible set of demands, if they are asked to store and apply manure with no environmental impact - with current technology, even the best manure management system adds something undesirable into the environment, at some level.**

Figure 1: Potential Pathways for the Movement of Manure or its Components on Farms

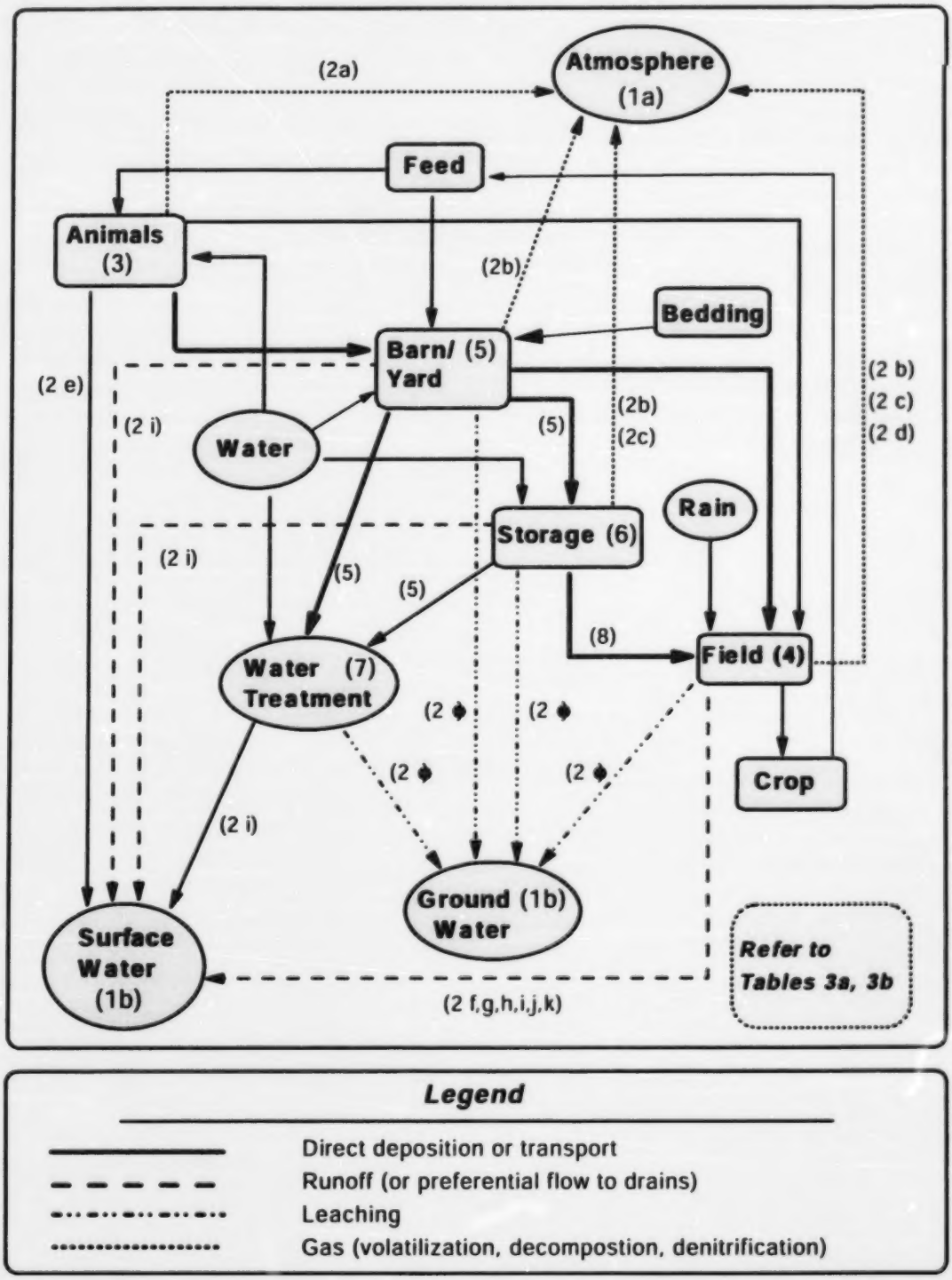


Table 3a: Environmental, Animal and Agronomic Factors Relating to Manure Use

1: Contaminants	2: Contamination Processes	3: Livestock Types	4: Management Factors
a) Air:	Air:	Dairy:	Cost
NH_3	a) Digestion	Milking Cows	Climate
CH_4	b) Decomposition	Dairy Cows	Distance to:
CO_2	- Aerobic	Heifers	- barn
NO_x	- Anaerobic	Calves	- neighbours
H_2S	c) Volatilization	Beef:	- watercourses
Odours	d) Denitrification	Cow-calf	- wells
		Stockers	- watertable
b) Water:	Water:	Feeders	Soil:
NH_3	e) Direct	Swine:	Texture
NO_3	f) Spills	Farrowing	Structure
Bacteria	g) Drift	Finishing	Drainage
Solids	h) Misapplication	Poultry:	Topography
Phosphorus	i) Runoff	Layers	Fertility
	j) Erosion	Broilers	Compaction
	k) Macropore Flow	Turkeys	pH
	l) Leaching	Hatching Eggs	Crop rotation
		Ducks/Geese	Tillage system
		Sheep	Pest Control
		Goats	Convenience
		Horses	Labour
		Fur-bearers	

Table 3b: Options in Handling, Storing and Spreading Livestock Manures

5: Collection and Transfer to Storage	6: Storage	8: Loading, Transport & Spreading Equipment
Solid:	Covered or uncovered	Solid or Semi-solid:
Manure pack		Front-end loader
Manual	Composting	Box spreader
Litter carrier		Open tank spreader
Scraper	Solid:	Dump truck
Gutter cleaner	Earth	
Stacker	Concrete	Liquid:
Front-end loader		Pumps
	Liquid:	Auger
Liquid:	Concrete	Elevator
Cable scraper	Steel	Vacuum tanker
Water	Earthen	Pipeline
Slatted floor		Tanker truck
Front-end loader	Semi-solid: Concrete	Spreader tank wagon
Gravity		Injector tank wagon
Pumps	7: Water Treatment	Spreader tank truck
	Liquid Storage	Irrigation
	Tank-trench system	
	Artificial Wetland	
	Vegetative Filters	
	Irrigation	

Figure 2: Transformations of Manure Nitrogen Following Application to Soil

Table 4: Likely Effect of Current BMP's for Manure Application on Environmental Contamination Through Various Processes Other Complicating Factors

Concern BMP	Rnf *	Prf Flw *	Lch *	NH_3 Vol *	DeN *	N Avl *	N Eff *	Cmp	P&K Exs	Complicating Factors
Add bedding	- 	- 	-? *	- *	+? *	-? *	+? *	-?		Cost & availability. Nutrient content can be more variable. Can affect spreading characteristics. Increased immobilization and denitrification, if high C/N.*
Compost	-	?	- *	? *	?	-? *	? *	-		Cost. Labour. Not suitable for all types of manure.* N in stable compost slow to mineralize.
Supply 75% of N from manure	-	-	-	-	-		+		-	Could require additional land. Determining nitrogen supply in soil.* Determining ability of manure to supply nitrogen.*
Spread evenly	- *	-? *	-		-		+		-	Variable composition, especially from uneven mixing. Limitations of spreading equipment.* Effect of wind on distribution of liquid manure.*
Spread when soil is dry	- *	- *		?			+	-		Weather; wet soil when manure should be spread. Timing conflicts with other field work. Can require increased storage capacity.
Improve drainage	-?	?	+?		-		+	-		Cost. Soil Texture.
Spread on bare, unfrozen soil	-			?			+	+?		Will require increased storage capacity. Adds to work scheduling conflicts.
Match time with crop demand	? *	? *	- *		- *	+? *	+? *	+?		Timing conflicts with other field work. Soil may not be dry enough in early spring. Can require increased storage capacity.
Till soil before applying liquid manure	- *	- *					+? *	+?		Adds to work scheduling conflicts. Might not be compatible with no-till systems.* Could increase risk of recompaction of topsoil.
Incorporate within 24 hours	- *	- *		-			+			Adds to work scheduling conflicts. Not compatible with no-till systems.*
Inject liquid manure	- *	-? *	? *	-	+? *		? *			Cost. Can leave soil very rough.* Possible denitrification in manure band.
Irrigation of liquid manure	? *	? *		+			?	-		Increases odours & losses from ammonia volatilization.* Tendency to overapply.
Mulch Tillage	- *	-? *	? *	? *	?	? *	? *	?		
No Till	+ *	+? *	? *	+? *	+?	? *	? *	? *		Difficult to incorporate manure into soil.* Soil moisture contents tend to be higher.
Use cover crops			- *		-		+? *			Questionable effectiveness.* Timing of nitrogen release may not match crop needs.* Not compatible with some crop rotations. Usefulness reduced in systems using fall tillage.*
In emergencies, spread on hay/ grass in summer	?	?	?	+	?			–		Risk of runoff. High loss of nitrogen from volatilization. Can overstimulate grasses in grass-legume stands.

Title Abbreviations (in order): Runoff; Preferential flow; Leaching; Volatilization; Denitrification; Availability of nitrogen to subsequent crop; Efficiency of nitrogen utilization: Soil compaction; Excessive phosphorus or potassium levels in soil.

(-) reduction expected: (+) increase expected; (?) effect unclear or variable

* Information available or expected from Green Plan projects.

Table 5a: Environmental, Agronomic and Management Aspects of Manure Use on Land, Addressed by Green Plan Projects
(16 projects involve manure directly; 18 other related studies should also provide relevant information)

Management Area Concern	Measurement or Prediction	Nitrate-N Soil Test	Application Methods	Tillage	Cover Crops	Livestock	
						Species	Ration
Surface Runoff Water Quality (related studies)	GLWQP: 10 L MA 05/97 L RF 02/97 L (RF 03/97) (MO 10/97)		GLWQP: 10 L RF 02/97 L	MA 05/97 L RF 02/97 L RCC: 72 L			
Preferential Flow (related studies)	GLWQP: 10 L LSII: 66 L MA 05/97 L RF 02/97 L (NSCP: 3,4) (MO 10/97)		GLWQP: 10 L MA 05/97 L RF 02/97 L (NSCP: 4)	GLWQP:10 L MA 05/97 L RF 02/97 L (RCC: 72) (NSCP: 4)			
Nitrogen & Carbon Transformations	LMAP 13/94 L MA 02/97 B MA 04/97 B		MA 04/97 B		LMAP:13/94 B	MA 2/97 B	MA 2/97 B
Nitrate Leaching: Manure Studies (related studies)	MA 03/97 S MA 05/97 L	NSCP: 7 B RF 02/97 L	MA 03/97 S LMAP:13/94 L MA 05/97 L RF 02/97 L NSCP: 7 B (MA 04/97) B	LSII: 113 B NSCP: 7 B	LSII: 113 B NSCP: 7 B LMAP:13/94 B	MA 2/97 B	MA 2/97 B
Related Nitrogen Mgt. Studies	LS 7020 LS 7017 LSII: 100 GLWQP: 9,12 LMAP 15/94	LS: 7020 LSII: 26,29e LSII: 100 RF 05/97	GLWQP: 9	GLWQP:9,11 NSCP: 5 LMAP 15/94	GLWQP: 9 LS: 7017 LSII:59, 29d LSII: 100 LMAP 15/94 RF 06/97 RCC: 115		
Nutrient Content and/or Crop Response		LSII: 40 B NSCP: 7 B	NSCP: 6 S RCC: 29 S MA 03/97 S MA 05/97 L RF 02/97 L RCC: 72 L LSII: 40 B LSII: 99 B NSCP: 7 B MA 04/97 B	LSII: 113 B MA 05/97 L RF 02/97 L	LSII: 113 B LMAP:13/94 L NSCP: 7 B	LSII:113B LSII: 40B MA 3/97 S RF 2/97 L MA 4/97 B	MA 4/97 B
Plant Pathology	MA 10/97 B					MA10/97B	
Costs			MA 03/97 S RCC: 72 L GLWQP: 10 L MA 02/97 B				
None of these projects directly considers the effects of manure application on other soil properties. Results of several projects under "Development of Methodologies to Evaluate Soil Quality should be useful in this regard.							
The literature review, "Current State of the Art on Manure/Nutrient Management" (MA 01/94), contains information relating to most of these concerns and lists gaps in the current information.							

S: Solid Manure L: Liquid Manure B: Both Liquid and Solid

Table 5b: Projects Related to Manure Storage, Handling and Application

A: Treatment of Contaminated Water Through:

Vegetative Filters:	RCC 124 (milkhouse); RCC 102 (runoff)
Treatment Beds:	LSII 28 (milkhouse)
Constructed Wetlands:	RCC 15 (milkhouse); RCC 98 (runoff); RCC 90 (both)
Irrigation:	RCC 33 (lagoon effluent)

B: Carbon and Nitrogen Transformations

MA 02/97 effect of livestock species, ration, storage facilities, bedding & handling method on changes in manure nutrient content, notably carbon and nitrogen

C: Composting

NSCP 6 comparison of methods, including costs, carbon and nitrogen
MA 03/97 transformations, and utilization

LSII 74 on-farm demonstration of passively aerated composting

D: On-farm Surveys of Manure Nutrient Contents and Application Rates

LSII 40
LSII 99

S))))))

Ontario Field Crop Recommendations,
several of the Best Management Practices booklets,
a number of the 28 OMAFRA Factsheets that relate directly to manure and
several other OMAFRA publications related to nutrient management.

None of these sources address the complete manure management system. Faced with a set of apparently conflicting or contradictory demands and no clear way to resolve them, it is easy for farmers to ignore them all and continue to use the system they find most convenient and/or economical. Farmers generally accept that they should minimize the impact of their activities on the environment. However, with no comprehensive aid to assist farmers in integrating all of the factors into an optimum total system, how are they to chose among the available options?

A Review of Technology Transfer in Ontario

(The following analysis and comments was influenced considerably by SWEEP Report # 7 *Sources of Motivation in the Adoption of Conservation Tillage*. Otherwise, they are based upon my personal experiences, observations and perceptions, not the result of any particular research, unless specified.)

In the traditional model of technology transfer, sometimes referred to as the "Adoption-Diffusion Model", information is perceived to flow in steps from researchers/developers through a recommending body, to public sector extension personnel or private sector sales representatives and then to farmers (Figure 3). At the farm level, new technology is seen to be applied first by "innovators", followed closely by "early adopters" and then to spread gradually throughout most of the farm population. (Almost no technology will be universally employed).

S))))))

This model was developed in an era when information probably did flow mainly in this linear fashion (e.g. 1950 - 1970). The level of information, and the system that delivered it, suited the times and technology was transferred very effectively. Ontario agriculture changed gradually, but dramatically, over the course of 20 years or so.

Many factors combined to make the new technology relatively easy to "sell".

Information was limited and few management options were available. Extension personnel delivered a standard, relatively simple package of management recommendations, on a wide range of topics, to a fairly homogeneous farm population (i.e. mainly small, mixed, family farms), through a limited number of a media (primarily print, meetings and personal contact).

Recommended changes were relatively simple to implement, tended to deal with components of the production system individually, and were adaptable to a large proportion of the farms. Once a new practice was demonstrated by innovators, it could be readily adopted by many neighbouring farmers. There was little need to target information to specific clients (except among commodity groups) because most farmers used a similar set of technologies and thus, would obtain similar results from a change. Most changes had the combined benefits of improving production and reducing the amount of physical work required, without making management of the farm system much more difficult. For the most part, the new technologies could be tried with existing equipment without disrupting the whole farming system. (For example, one could try 2,4-D on their grain or 10-10-10 on corn without worrying about what crop would be grown next.)

Farmers looked to extension personnel for advice, because they had the best information available. Furthermore, because other channels of communications were not as developed as they are today, farmers had almost no other source from which to obtain new information.

<u>The OASCC System</u>

Within Ontario, an elaborate system of committees and sub-committees has been established to coordinate agricultural research and the formulation and delivery of recommendations. In theory, this coordination is provided by the Ontario Agricultural Services Coordinating Committee (OASCC), the eight Research and Services Committee which report to it and their sub-committees. (See Appendix F.) In many cases, review of research results and other information, and the drafting of recommendations is done by sub-committees of these sub-committees.

It is doubtful if any of the premises that appear to underlie the OASCC system are completely valid today.

It would appear that the OASCC system presumes that:

1) *agricultural research in Ontario is funded primarily by OMAFRA and AGRICULTURE AND AGRI-FOOD CANADA.* Thus, most of the decisions as to which research projects should be undertaken and the appropriate level at which to fund them can be channelled through the OASCC system.

   i) In fact, a large proportion of research in Ontario, even at public institutions, is funded by sources other than OMAFRA or AGRICULTURE AND AGRI-FOOD CANADA. Much

funding comes from other ministries and the private sector, including both agri-business and farm groups. Usually, such funding is targeted to addressing specific topic or policy questions, which are not necessarily those identified as priority areas within OASCC. Because each of these sources of funding has its reporting mechanism, results of these projects often are not reported through OASCC and thus, may not be integrated into recommendations.

2) *agricultural research is conducted primarily by scientists at research facilities operated by AGRICULTURE AND AGRI-FOOD CANADA, OMAFRA or The University of Guelph.*

i) Much research is conducted by the private sector and thus is not directly available to OASCC committees, especially that dealing with products covered by proprietary rights.
ii) A substantial amount of research that affects agriculture, at least indirectly, is done within other government ministries or agencies and other universities. Little of this information is fed through OASCC.

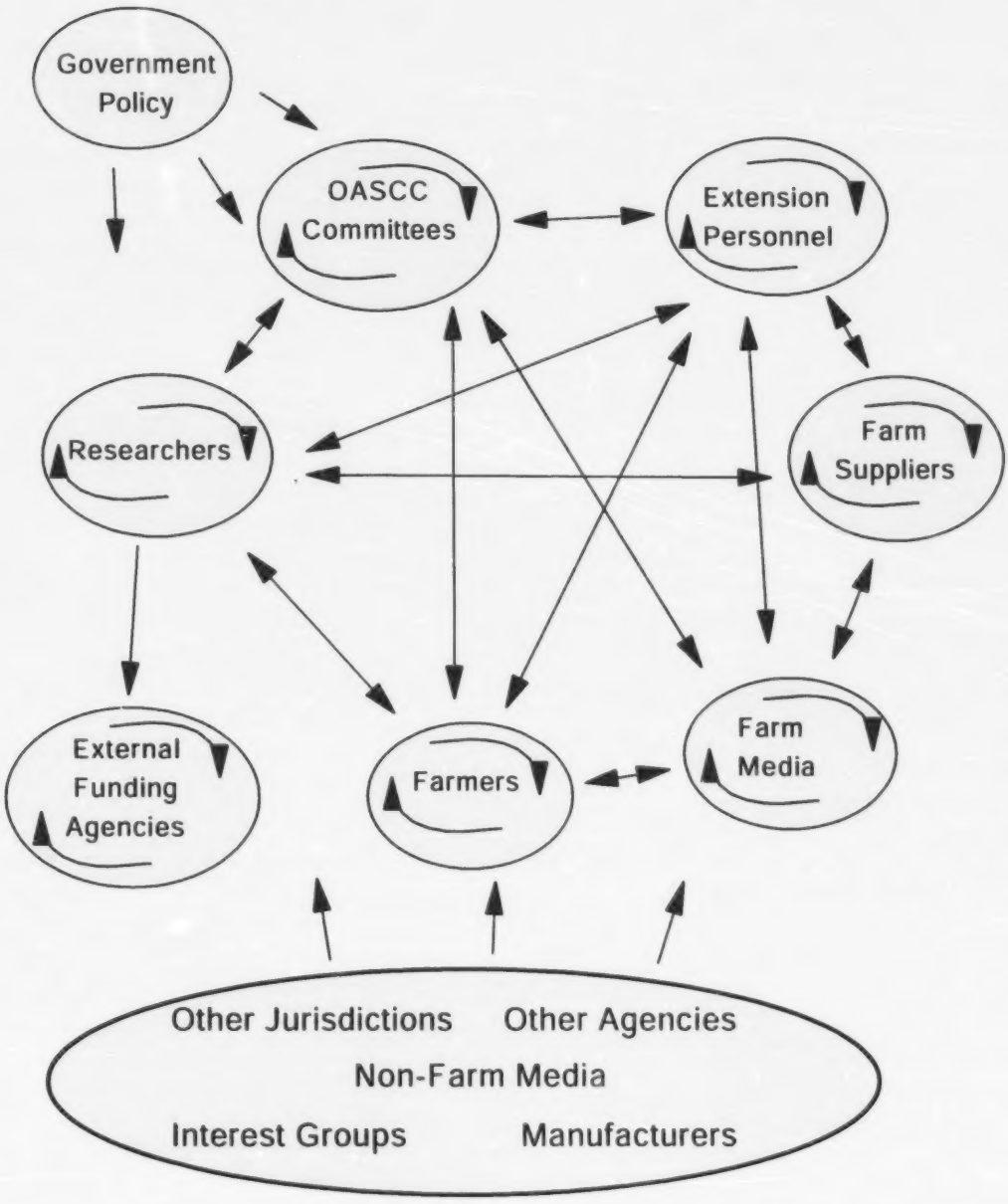
iii) Much technology development, if not invention, occurs on the farm. Often, this work addresses questions at the leading edge of environmental issues. Unfortunately, such work usually comes to the attention of OASCC committees, if at all, only as the result of questions being addressed to researchers or extension personnel by the innovators involved. Although, design of many of these experiments makes it difficult to integrate the results into the OASCC system, the information generated can be very relevant and useful. Indeed, some innovators must be recognized as our best experts on certain technologies.

3) *that research results and subsequent recommendations flow outward from OASCC committees towards farmers, more or less, according to the traditional Adoption-Diffusion model discussed above.*

i) This is progressively becoming less true, as the number of other sources of information and other communications avenues continue to increase. Because technology is being developed or adapted at almost all levels of the OASCC system (i.e. researcher, extension, private sector and farm) and at a multitude of sources external to it, information flow is increasingly multi-directional (Figure 4). Indeed, technology developed on farms would seem to flow "backwards" (ie. from farmers to researchers), if one were to attempt to apply the traditional extension model.

ii) Much information either bypasses the OASCC system or is essentially "lost", in part because of the reasons outlined above, but more particularly because no one has the assigned responsibility to collect and summarize it. Formerly, much of this was done by extension coordinators at OAC or by OMAFRA Specialists. Now, the former positions no longer exist and the latter increasingly have less time to do so.

Figure 4: Current Patterns of Information Flow



iii) Agri-business is both a significant source of information and an essential vehicle for distributing information, much of which reaches the farm without independent review. Unfortunately, technology that does not lend itself to commercialization tends to be under-extended.

iv) The farm press, including magazines and newsletters from farm associations, have become a key source of information for most farmers While the mass media are excellent for creating awareness, they are not a suitable vehicle for the level of detail required to implement technology at specific farms.

Preferred Information Sources Among Farmers

In transferring detailed information, our system remains highly dependent upon personal contact, which is the preferred method of learning of many farmers.

In Ontario, the extension system has relied heavily on printed resources and personal contact. Generally, the former have been quite effective in raising awareness about issues and the availability of new information. Because of the diversity among farms, printed resources tend to be less effective for providing detailed, farm-specific information about how to implement a new technology, especially if it is complex.

The reliance upon personal contact to transfer detailed information was confirmed by the recent Decima survey regarding Best Management Practices (as well as by SWEEP Report # 8 *Social Structure and the Choice of Cropping Technology* and the Green Plan Phase 1 Evaluation *Benchmark Survey Report*).

In the Decima Survey, farmers were asked to name the best two media sources for receiving information about: a) trying a new technique or b) implementing a new technique. They rated the following most highly:

	Try	Implement
Visiting Successful Farm Operators	42%	34%
Communications with Experts	32%	34%
Demonstration Tours	30%	27%

Only 20% of the farmers surveyed rated either seminars/workshops or Factsheets as the one of the two best media for transferring detailed information. Magazines were the most popular means of obtaining general information about a topic, but their perceived usefulness declined as the level of detailed required increased. Videos and government publications each were highly rated by only 10-15% of the respondents, depending on the question.

Challenges Faced by the Current Extension System

The extension system has generally served Ontario agriculture well, and continues to do so despite the limitations noted above. However, these limitations must soon be addressed, since their effects will likely become more significant in the future.

Farmers will continue to request more specific and more detailed information.
Ontario's farms are much more diverse today than in the past, in aspects such as:

- enterprise mix.
- production system.
- tenancy.
- intensity of operation.
- business structure.
- technology available
- scale of operation

Farms have become so diverse and so specialized, that each farmer's informational needs are almost unique, in respect to both the questions to be answered and the level of detail sought. Few areas remain for which "blanket" recommendations can provide sufficient information to allow a farmer to implement the practice on his or her farm. In many cases, even "farm level" recommendations are not specific enough. Farmers increasingly need information that will help them in varying their management "field-by-field", at the least. As technology for variable rate application develops, the area which can be managed uniquely will become ever smaller.

Farmers will be more selective about the format in which they will accept information.
Farmers have become very diverse in their abilities to obtain, assimilate and apply information. They vary widely in:

- experience.
- education (both in terms of area of emphasis and level attained).
- literacy (and first language).
- management style and emphasis.
- off-farm work or responsibilities
- information sources accessible (local, national and international).
- preferred methods of obtaining information.
- communications vehicles available.
- mobility.

For any given technology, farmers at all stages of adoption will require information appropriate for their level of interest, at any given time.
With the introduction of new technology, potential users of it go through a continuum of stages that can be described as:

awareness.
consideration.
decision.
experimentation.
adaptation.
commitment.

Thus, while some farmers will be looking for the specific information they need to implement a technology, others will still require general materials to raise awareness and promote experimentation.

Increasingly, farmers will require a package of information complete enough for them to visualize how the entire system can be made to work, profitably, on their farm before they will try it.
In the past, recommended changes tended to deal with one component of a system at a time, with minor impact on other operational aspects, and required little investment for experimentation. Today, many of the changes being recommended necessitate simultaneous changes in many facets of the farming system. This seems especially true for technologies related to environmental protection. Rather than making the production system simpler, they tend to make at least the management of it more complex. For example, adopting a new tillage system can prompt changes in planting equipment, crop rotation, fertilizer application, pest control (especially, weeds) and manure application, at least. Even to experiment with a new technology can necessitate a large capital investment for a farmer and thus pose a large risk for him or her.

The amount of information now available and the level of detail being requested are beginning to seriously tax the system for extending information in Ontario. Farmers increasingly are facing problems requiring "expert" knowledge, over a more diverse range of topics, and are looking to contact an expert directly to assist them in answering these questions. Unfortunately, one-to-one service is a very costly means of technology transfer and is becoming progressively less available. With consolidation and down-sizing in both the public and private sectors, fewer researchers, extension personnel and sales staff are available to deliver personal service. In many regions, there is not enough extension or sales staff to provide assistance in all enterprises and on all technologies. One wonders how much longer it will be before farmers become dissatisfied with the current system. There is some evidence to suggest that is beginning to happen. For example, it is not unusual for those requiring detailed information to by-pass local extension staff and contact researchers directly or to seek information from another jurisdiction.

Despite the benefits, there are several risks associated with increased direct contact between innovators and researchers.

Researchers could develop a skewed perspective of the level of knowledge and management ability of farmers and the appropriate level of technology to advance to the broader farm population. The "gap" between the production systems used on the farms of innovators and those employed most commonly by other farmers appears to be widening. One wonders if the technology being developed or tested by some innovators is so different from that of the "average" farmer as to appear to the latter to not be applicable to their operations.

If the "experts" over-emphasize their contact with innovators at the expense of that with extension personnel, the latter could well become even further "behind". It can be easy to conclude, erroneously, that because some farmers are aware of a new technology, all farmers are aware of it, and devote less effort to the preparation of project summaries and extension materials (new or revised). (Preparing reports or releases is not a highly favoured activity among either researchers or extension personnel, so it is easy to forego.) Extension and sales staff still play a key role in extending information to the broader farm population, and therefore, need to be kept up-to-date, with information that is summarized

and presented in an easily accessible format. Otherwise, the need for each extension person, and perhaps, farmer to contact an expert directly to obtain detailed information will increase, putting further stress on the system. Needless to say, this would result in a very costly and inefficient extension system.

Those who become identified as "the expert" run the risk of being kept so busy responding to requests for individual service as to limit their ability to maintain their expertise. This is of a vicious circle - as the demands for personal service increase, researchers have even less time to write and extension personnel have less time to seek out the latest information or to prepare extension releases. As a consequence, the quality of the information available locally is more like to vary among regions depending upon the interest, skills and access of the local representatives in acquiring it.

Revitalizing the System

Despite its limitations, the current system for technology transfer in Ontario does represent a solid base upon which to make improvements. Much of the information required by our clients can be transferred using existing agencies, organizations and communications technology, with appropriate modification and supplementation. Even where the decision is made to develop new channels of communications, dissemination of much-needed information must proceed in the best way possible using the current framework in the meantime. In anticipation of the changes in communications technology that are occurring, however, extension materials should be produced in forms that will be readily adaptable to communications vehicles that are likely to become widely used within the next few years. (Where several vehicles appear to be equally appropriate, preference should be given to those that will deliver information most cost-effectively.)

Some changes need to be made within the system to address the following objectives:

Recommended Goals:

1) Information must presented in ways that will allow potential users to assess the impact of a change in technology on their production system and the environment.

2) An effective alternative to direct contact with experts must be developed to transfer detailed information to clients.

3) The technology transfer system must ensure that the best available information is widely accessible in formats that will facilitate widespread usage.

Recommended Objectives:

1) For each issue area, an individual, or group, should be assigned the task, and held accountable, to ensure that, as information becomes available, it is:
   - assembled at a central location, preferably in both printed and electronic formats.
   - reviewed and integrated with previous information, noting whether they support current recommendations or necessitate change.
   - summarized with previous information.
   - presented, with draft recommendations, to the appropriate OASCC committee for review.
   - available to extension personnel and private sector sales staff, in a readily usable form.

2) To ensure that the summarization of data in this manner will occur it is likely that funding will have to be provided specifically for this task, given the state of human resources in most organizations today. One way to address this would be to dictate that this would be the final project undertaken in all programs or components thereof.

3) Design of projects on related topics should be coordinated to facilitate integration of their results. Collection of a standard dataset should be encouraged, as appropriate.

4) Information from on-farm demonstrations and experiments should be integrated into the reviews outlined above. Use of a standard design for on-farm plots and collection of a standard dataset should be encouraged, especially where the work is conducted with public sector input (e.g. OSCIA and Rural Conservation Clubs).

5) Extension materials should be designed to meet the needs of specific client groups, with regard to the level of detail and format. These could range from printed materials, for raising general awareness, to computer databases linked through hyper-text for guiding users through complex implementation problems. In such materials, either printed or electronic, the pathway by which a user can obtain more information must be clear.

6) All extension materials related to a particular topic should be available, or accessible, through the same location. (Presumably, it will be a policy decision as to which ministry or agency will be responsible for specific issues.)

7) Production recommendations and related information should be organized and presented in ways that facilitate use of a systems-approach in considering and applying new technology. It does not appear feasible to attempt to transfer "packaged" systems, at this time, given the diversity and complexity of most farm operations, but clients should be able to obtain information on all components of the system they are assembling.

8) Extension material should outline the potential impact of a technology on both other parts of the farm system and the environment or indicate where such information can be obtained. Prerequisites for implementing the technology on a farm should also be identified.

9) Materials should be developed to assist farmers in comparing the costs and benefits of alternate technologies, objectively, relative to both farm and environmental goals (e.g. something akin to full cost accounting). Through such an approach, farmers should be able to arrive at a least-cost, practical system.